made by a citizen of London. Recorde dedicates the first English algebra to the company of Merchant Adventurers trading to Muscovia.

Important advances in mathematics were made by the professors at the college in London, founded by Sir Thomas Gresham. This feeling among the trading classes produced results in Italy which Libri tells us were unparalleled in any previous time. We all know of the Floral Games of Toulouse, and the athletic contests of the Greeks at Olympia and Corinth. But Libri tells us that just this interest, just this popular excitement was felt in Italy when Ferrari or Bombelli had made a step in advance in the solution of cubic and biquadratic equations. There were public challenges to contests of skill, proclamations by heralds, wagers to be decided. There is a collection of answers given by Tartaglia to questions submitted to him for solution by men from all ranks in society, princes, monks, doctors, ambassadors, professors, architects, and merchants, and a large proportion of them had to do with cubic and biquadratic equations. It may seem rather strange that this particular portion of Algebra should have excited so much interest, but it must be remembered that it is not possible to determine beforehand what researches into abstract truth will afterwards lead to the greatest practical benefits. There was a widespread belief that the new powers of calculation would bring about material advantage.

I trust that I may be pardoned for thus bringing forward matters which are no doubt very familiar to most of the members of this Association; but the object has been to give a sample of the kind of facts that would be likely to appeal to the minds of young learners, and to attach some human interest to the abstract subjects they are studying. This human interest is to be found in the history of navigation not less than in that of commerce. The relation between the commercial impulse and the navigation impulse was not exactly one of succession. The former was the earlier, then the two for a time went on together, and afterwards the latter was supreme as a ruling motive for promoting mathematics.

The two great problems in navigation were first, if you knew where you were, to find how you could best get somewhere else; and secondly, if you did not know where you were, to find this out by astronomical observation. The solution of the first was mainly dependent on maps and charts, and consequently for a long time men were hard at work making these for the use of sailors. The first great promoter of this work in modern times was Prince Henry of Portugal, called the Navigator, and after his death in 1460 to the close of the century, Portugal, eagerly engaged in the exploration of the coast of Africa, continued to be the great chart-producing country. Later on it was to the Netherlands that we were principally indebted for improvements in this direction, and in the long list of those thus engaged a prominent place is taken by Stevin. Mercator's projection is so called from Kauffman, who invented it in 1566, but did not clearly show the principles on which it is founded, a task that was afterwards accomplished by an Englishman, Edward Wright, whose great services to science have been but scantily recognised.

The second great problem—to find out where you are by astronomical observation—was a pressing question in the sixteenth and seventeenth centuries. The chief instrument the Elizabethan mariner had at his command was the astrolabe. This was made in very various forms. For use at sea, of course the simplest form was chosen. There is a plate in Hutton's Mathematical Dictionary of one, consisting of a graduated circle held up by a ring, and so keeping a vertical position by its own weight, furnished with an arm and two sights, by which the altitude of the sun, moon, or stars could be estimated. The astrolabes in use on land were fitted up with much greater refinement.

An instrument perhaps more frequently used, easier to work with than the astrolabe, but less accurate, was called the cross-staff or fore-staff. It was composed of a graduated wooden rod, about three feet long, with cross pieces sliding along it of different heights, and the angle was observed in the same way that a volunteer uses the sights on his rifle. This fore-staff could be applied to roughly determine the distance between two stars.

To determine with any accuracy a ship's place at sea, three things are requisite. First, a theory that is true and workable as far as it goes; secondly, means of observation; thirdly, means of calculation. A defect in any one of these requisites renders comparative excellence in the other two of small use. Now, the mariners of Drake's time had scanty theoretical knowledge, poor instruments, and very deficient means of calculation. They could, in a rough fashion, find out in about what latitude they were; the longitude remained a mystery.

It was at the beginning of the seventeenth century that the first great improvement took place. The invention of logarithms, by Napier, placed the calculating power at one bound far in advance of either the theoretical knowledge or the means of observation. His system, further developed by Briggs, the Gresham professor, so completely supplied the want previously existing, that any improvements made between then and the present time are mere matters of detail.

The improvements in theory and in instruments went on gradually and together. Tycho Brahe did much to advance the efficiency of instruments, and every step in this direction gave the means of correcting or developing previous defective theory, and each theoretical advance suggested or rendered possible some new instrument of observation. It is no proper part of my subject to trace the steps of this progress. It is sufficient to say that now the shipmaster, often a man of no great scientific attainments, generally accustomed to work by rules, the reasons for which he does not know, has in his cabin a chronometer and a book of navigation tables, which represent in a material form the genius and the toil of the master minds that have arisen during the centuries of the past.

In the application of pure mathematics to navigation, as well as to many other purposes, it is curious to notice the changes in the relations between graphic methods and calculation methods. At first the former greatly predominated. The quantities of straight lines and curves engraved on Drake's astrolabe, the profusion of scales on old sun dials, that but few thoroughly understand, were originally intended and were accepted as the most simple means of determining practical problems. They gradually gave place to numerical calculation, but not very quickly. Fifty years ago a boy's training in the elements of navigation was conducted far more on the lines of geometrical construction than it is at present. In quite recent times there has been a revival of graphic methods in a somewhat different aspect. Besides the value they have always had for illustration and explanation, it has been seen that there is a special field for them in cases where calculation would be long and troublesome, and this special field is being clearly marked off.

The correspondence between the practical aims of men and the progress of theoretical knowledge and of means of calculation does not stop with navigation. In recent times the need for more powerful or more exact machinery, the employment of steam and electricity, our increased knowledge of what is meant by heat and light have had the effect of demanding fresh advances in mathematical methods; or, perhaps, more exactly of selecting from the mass of abstract truth acquired for its own sake the particular portion suited to the special purpose. These influences have had, however, nothing to do with the schoolboy's elementary programme, and are, therefore, outside the immediate subject of this paper.

In conclusion, I would urge that if there is any sound foundation for the views that have been expressed, we ought not in England to be without some elementary primer of the History of Mathematics.

FOGS AND HORTICULTURE.

PROF F. W. OLIVER'S second report on the effects of urban fog upon cultivated plants has been presented to the scientific committee of the Royal Horticultural Society, and is now printed in the Society's Journal. The following is the passage in which he deals with possible remedial measures:—

> There is very little of what I can say likely to be consoling to the horticulturist. We must recollect that in the employment of measures directed towards mitigating the injuries incident to fog, two factors—the presence of poisons in the atmosphere and the reduction of light—have to be considered. To counteract these the urban cultivator is asked to construct air-tight houses, with definite openings where the admitted air can be filtered; whilst to compensate for the loss of light due to the absorption which the rays undergo in traversing a stratum of dense fog, he must provide a generous installation of electric light. Without doubt, the entire preservation of vegetation in foggy weather is only a matter of *£ s. d.* But it is for the cultivator to sit down

and count the cost. Representative growers agree in advising me that although horticulture, under these conditions, would be very interesting from a scientific point of view, it would hardly be commercially desirable. The necessity for the reconstruction of glass-houses upon valuable urban land must of necessity suggest to the horticulturist the alternative of decamping into the country, where the cultural conditions are more favourable. The enhanced value of urban sites has, apart from other inducements, no doubt been a factor in determining an increasing number of growers to settle well outside the suburbs. If, then, any idea of reconstruction is raised, it would in all probability prove to be the last straw. Considerations of this sort lead me, in making a few remarks upon cultural precautions, to limit my suggestions to such as are possible of realisation—things being as they are.

If we could eliminate atmospheric contamination, I do not think the reduction of light alone would be a very serious cause of complaint. Now and then it might be so to some extent, though it would hardly be a grievance of the first magnitude. It is when we have superadded aërial contamination that the mischief is done. Many very common injuries to flowers—injuries which impress the cultivator and catch his attention—have no casual relation with diminished illumination. The inflorescences of rhododendrons, which become so characteristically glued up in their bud-scales and fail to open, will expand perfectly in total darkness. So also will the flower-buds of most orchids. Since, however, the application of artificial light, in a manner likely to be effective, would be an unduly heavy burden on the grower, we will dismiss this aspect of the question, and proceed to discuss whether atmospheric contamination can be cheaply remedied.

And, first of all, can fog be neutralised or absorbed after it has entered a plant house? I have experimented with several things, but my results do not justify me in basing any recommendations upon them. The sluicing or syringing of liquid chemicals about a house has little to recommend it, even when attended with some success. To solids the objection is not so great. But I have not found that carbonate of ammonia, for instance, exerts any noticeably beneficial action as a neutraliser of the acid vapour of fog. But fog is a complex product, and anything which might neutralise one constituent would probably leave the others free to do their damage. I have never felt that anything could be done inside the house towards mitigating fog except the taking of certain precautions as regards watering and heating. And I am of this opinion still.

The scope of this report does not extend to a discussion of the big question of the abolition of fog. Even the most sanguine of the present generation can hardly hope to enjoy any abatement of the fog-nuisance. So that I shall be more practically discharging my mission in discussing how fogs may be excluded from plant-houses than in attacking the greater problem. Stoves, within certain limits, can be covered in with sheets of canvas, and this has been tried with encouraging results. I first heard of this method being systematically and successfully applied from Mr. C. Davies, of the Mote Park Gardens, Maidstone. Even the fogs of limited duration which are experienced there are sufficient to destroy the blossoms of a whole houseful of orchids. But they have been successfully combated by covering in the house with canvas sheets. Elsewhere I have seen this done, sometimes at my suggestion, with beneficial results. Still, at the best, it is but an expedient. Immunity obtained in this way is only partial. Severe fogs of short duration, or longer ones of only moderate density, may be filtered through canvas, so that the damage caused is lessened; but a persistent dense fog generally prevails in the end.

If plant-houses were constructed rather less leaky than is the case at present, something definite could no doubt be done towards filtering the air. I confess to holding serious doubts as to whether the admission of air to plant-houses, as in vogue just now, is based on sound physiological principles—and this quite apart from the fog-nuisance. During the course of my inquiries into fog, a device for ventilating conservatories—the "patent fog-annihilator" of Mr. Charles Toope—came prominently under my notice; and as I have been frequently asked what I think of it, I will take this opportunity of stating what I know. The system is as follows: A number of boxes, situated on the floor under the staging, communicate directly with the exterior by means of aperatures which can be readily closed if desirable. These boxes contain several open-work trays, upon which sticks of charcoal are loosely placed. The air entering a box from outside is led through these trays, coming into close contact with the charcoal. As the air leaves the box it impinges upon the hot-water pipes, and is thus warmed before it reaches the plants in cultivation. The entrance of air is promoted by simple contrivances known as "exhaust-caps" placed on or near the ridge of the house. These caps are so constructed that practically, under all conditions, an out-draught of air obtains. Should the draught be too great, it can be regulated by means of valves. By this system a constant circulation of air throughout the house is brought about. The air enters the charcoal-box at once from outside. It passes through this and is warmed by the hot-water system of the house, and ultimately escapes by means of the "exhaust-caps." Excepting for the apertures mentioned the house is air-tight. It is by means of the charcoal that Mr. Toope claims that the air admitted is purified. As the air circulates between the sticks of charcoal it gives up the products of coal-combustion with which it may be contaminated, as in foggy weather.

Charcoal undoubtedly possesses remarkable properties as an absorbent, and Mr. Toope is by no means the first to call attention to its properties in this respect. Forty years ago the chemist Stenhouse[1] made observations on these properties, and it may not be without interest to call attention to what he said about it. In the paper referred to, Stenhouse describes and illustrates the remarkable property of charcoal as an absorbent and oxidiser of the products of decomposition of organic matter. He describes how the carcases of dogs were kept covered with a thin layer of powdered charcoal—but otherwise exposed—without any nuisance arising therefrom. He adds that he has devised a respirator on this principle, to be used in districts smitten with cholera or yellow fever. He found, further, that with such a respirator he could breathe with impunity air containing large amounts of ammonia, sulphurrtted hydrogen, and other hurtful gases. Finally, he suggested the application of charcoal for purifying the air of houses located in infected districts—all air admitted to be passed through thin canvas bags containining crushed charcoal. Were such precautions taken, many regions at that time fatal to Europeans could be, he was sanguine, dwelt in with impunity.

In a later paper[2] Stenhouse describes his experiments, showing how the absorbent property of charcoal could be greatly increased. From this paper I venture to make the following extract, as charcoal seems to have fallen into desuetude as an absorbent:—

"The lighter kinds of wood charcoal, owing to the nine volumes of oxygen gas contained in their pores, possess a considerable power of oxidising the greater number of easily alterable gases and vapours. The absorbent power of charcoal is comparatively much greater than its capacity for inducing chemical combination. In this respect charcoal presents a remarkable contrast to spongy platinum, which, though inferior as an absorbent for some gaseous substances—such, for instance, as ammonia, of which spongy platinum absorbs only thirty volumes, while charcoal absorbs ninety—is, nevertheless, immensely more effective both as an oxidiser and as a promoter of chemical combination generally. As it is desirable, for some purposes, while retaining the absorbent power of charcoal unimpaired, to increase its oxidating influences, it struck me that this important object might be easily effected by combining the charcoal with minutely divided platinum. In this way a combination is produced to which I have given the name of platinised charcoal, which possesses the good properties of both of its constituents. In order to platinise charcoal, nothing more is necessary than to boil the charcoal, either in coarse powder or in large pieces, in a solution of bichloride of platinum, and when the charcoal has become thoroughly impregnated with the platinum, which seldom requires more than ten minutes or a quarter of an hoar, to heat it to redness in a closed vessel—a capacious platinum crucible being very well adapted for this purpose. When 150 grains of charcoal were impregnated with nine grains of platinum, by the process just described, the charcoal was found to have undergone no change in its external appearance, though its properties had been very essentially altered. . . . I find that two per cent. of platinum is sufficient to platinise charcoal for most purposes. Charcoal containing this small amount of platinum causes a mixture of oxygen and hydrogen to combine perfectly in about a quarter of an hour, and this is the strength of platinised charcoal that seems best adapted for charcoal disinfectant respirators . . . . Platinised charcoal seems likely to admit of various useful applications; one of the most obvious of these is its excellent adaptability to air-filters and respirators for disinfectant purposes." So much for the properties of charcoal. My colleague, Prof. Corfield, of University College, assures me that "charcoal is now very little used for the purification of foul air. It was formerly employed in sewer ventilation, but it was found that it soon became damp and was then useless.

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[1] J. Stenhouse, "Ueb. die entfärbenden und disinficirenden Eigenschaften der Holzkohle, nebst Beschreibung eines Kohle-Respirators zur Reinigung der Luft durch Filtration," *Annalen der Chemie und Pharmacie*, Bd. xc. 1854, p. 186.

[2] J. Stenhouse, "On Platinised Charcoal," *Journ. Chem. Soc.* viii. 1856, p. 105.

I was anxious to test Mr. Toope's application, and to see how far the sulphurous acid of fog might be absorbed as the foggy air passed through the charcoal trays. Mr. Toope, therefore, at my request, furnished me with a sample box, so arranged that I could aspirate air throught it. I was frequently in the habit of aspirating fog through 25 c.c. of potassium permanganate of such strength that the aspiration of $2\frac{1}{2}$ to 3 cubic feet of an ordinary fog would decolorise the solution, whilst $1\frac{1}{2}$ to 2 cubic feet sufficed in the case of very severe fogs. I have repeatedly aspirated air, in all sorts of foggy weather, through the charcoal box. But even in the most severe instances I have never noticed anything more than a slight discoloration of the permanganate after the passage of as much as 25 cubic feet. I have also placed the box in a chamber into which an atmosphere of strong sulphurous acid was introduced—an atmosphere of which $\frac{1}{60}$ cubic foot sufficed to entirely decolorise the permanganate. When drawn through the charcoal, however, 3 cubic feet could be drawn without perceptibly affecting the colour of the fluid. When kept in an atmosphere of strong sulphurous acid the charcoal becomes in time charged, and, for the time being, incapable of further absorption. In this charged condition I left the box for some eight or ten weeks, and found that by the expiration of that time it was as good an absorber as ever. With ordinary fogs there seems little fear of anything of this kind happening; nor have I observed any tendency in the charcoal to get choked in this way in long spells of foggy weather. That other impurities are also absorbed I have no proof, though I consider it most probable.

In order to demonstrate the advantages of his system to horticulturists, Mr. Toope has constructed a small conservatory at his offices in Stepney. Here he cultivates, in an unfavourable atmospheric environment, a collection of orchids and other stove plants. The results I regard as distinctly favourable to his system, though they were not by any means convincing. This arose, not necessarily, from any defect in the filtering apparatus, but rather from faulty cultural methods. Mr. Toope is a busy man, and the charge of his plants falls to the lot of others. Many plants very sensitive to atmospheric impurities, which he obtained at my suggestion, received a severe check in transit before they reached him. Others, again, which he raised from seed for observation were liable to neglect from time to time. So that a casual visitor unacquainted with the facts might easily have carried away an unfavourable impression of the utility of the system. But, taking everything into consideration, I incline to take a distinctly favourable view of charcoal as a filter for contaminated air—so much so that I believe it might be adopted with advantage by our urban cultivators. The charcoal undoubtedly absorbs a very large percentage of the sulphurous acid, and this can only have a beneficial result. The adoption of the system to old plant-houses does not involve any very serious reconstruction. The charcoal-boxes and exhaust-caps are easily fixed; whilst it is only very old and leaky houses that cannot be rendered reasonably airtight. In this way the toxic action of fog will, I am confident, be mitigated to an appreciable extent.

As regards cultural precautions to be observed in foggy weather, experience indicates that a low temperature and a moist atmosphere are conducive to the well-being of the plants, though they, of course, afford no absolute protection. This aspect of the question has been clearly put in the following note from the *Gardeners' Chronicle* by Mr. Thiselton-Dyer, which I venture to quote *in extenso*:—

"The Kew practice of keeping the winter temperature of the houses as low as we dare is based on the result of practical experience. I do not dogmatise for other people who want to solve their own problems, and find out what is best for their particular requirements for themselves. But, as Mr. Henslow has pointed out, the theory of the subject has been stated clearly by Lindley; and it may not be amiss to quote a few words from his classical 'Theory and Practice of Horticulture' on the subject.

"The point of the whole matter is that in winter, with a low external temperature and nocturnal radiation, it is practically impossible, in a large glasshouse, to keep the internal atmosphere humid with a high temperature. I quote from Lindley, p. 207:—

"'Another source of dryness is the coldness of the glass roof, especially in cold weather, when its temperature is lowered by the external air, in consequence of which the moisture of the artificial atmosphere is precipitated upon the inside of the glass, whence it runs down in the form of "drip."'

"Again, 'It is evident that the mode of preventing this drying of the air by the cold surface of a glass roof will be either by raising the temperature of the glass, which can only be effected by drawing a covering of some kind over our houses at night, so as to intercept radiation, or by double glass sashes; or else by keeping the temperature of the air as low as possible, consistently with the safety of the plants, and so diminishing the difference between the temperature of the external and internal air.'

"In large glasshouses it is obviously impracticable to adopt the expedients which Lindley suggests. The only alternative is to do what we do at Kew—lower the temperature as much as possible, and so secure the highest possible relative humidity, with the double result of keeping the plants at rest and of checking their desiccation."

I hope shortly to issue a third report dealing with the fog question from its purely local aspect, including lists of plants which suffer and the area around the metropolis to which these special injuries are observed.

In due time I shall prepare a very detailed report or monograph, illustrated from the large series of drawings which I have accumulated. It will only be in such a detailed monograph that I shall be able to justify many of the statements which occur in the body of this, the second report.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Cambridge.—Mr. Pendlebury, of St. John's College, has been reappointed a University Lecturer in Mathematics, for five years, from Lady Day 1893. Prof. Macalister, President of the Anthropological Institute, has given three lectures this term on Physical Anthropology as follows: April 27, "The Races of Australia;" April 29, "The Ancient Egyptians;" May 2, "The Prehistoric Races of Britain."

The Professor of Pathology announces a practical course of instruction in bacteriology, to be given during the ensuing long vacation, by Prof. Adami, Dr. A. A. Kanthack, Dr. Wesbrook, and Mr. L. Cobbett.

Mr. J. Y. Buchanan, F.R.S., will deliver the second part of his course of lectures on oceanography at noon on Tuesdays during the present term.

The Smith's Prizes are this year awarded to three mathematicians, who are bracketed, namely, C. E. Cullis, B.A., of Caius, for an essay "On the Motion of Perforated Solids in an Incompressible Liquid"; D. B. Mair, B.A., "On the Continuous Deformation of Surfaces"; and R. H. D. Mayall, B.A., of Sidney, "On Certain Forms of Current Sheets." Mr. Mair and Mr. Mayall were bracketed Second Wranglers, and Mr. Cullis bracketed Seventh Wrangler in the Mathematical Tripos of 1891.

SCIENTIFIC SERIAL.

American Meteorological Journal, April.—Ice columns in gravelly soil, by Prof. C. Abbe. During spring and autumn little slender columns of ice are found at the surface of gravelly soils in moist places after a clear cool night, and the surface layer is found to be raised up an inch or two. Prof. Abbe offers an explanation of the phenomenon, which differs from that given by Leconte and others. The subject is of some importance to agricultural soil physics.—The diurnal variations of barometric pressure, by C. J. Lyons, of the Hawaiian Weather Bureau. The author takes into account the expansion of the air both upwards and laterally, caused